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The Status of Race Specialization in Yellow Rust, Puccinia glumarum (Schm.) Erikss. et Henn. in Europe

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At the first European Conference on Yellow Rust, the problem of specialization was given much attention. Cambridge, Holland and Braunschweig are prominent in this work.

Rudorf (11) was the first to report it for yellow rust. Allison and Isenbeck (1) and later Wilhelm, Gassner and Straib (5, 6, 7) studied the race flora of Germany on differentials. Beginning in 1934, Straib (13, 14, 16, 18) continued this work alone. In a search for other methods of differentiation than inoculation and evaluation of differential susceptibility, Straib (14, 16, 17, 18) found differences in individual races in uredospore germination, in reference to germination temperature optimum and the form of germ tubes. On the basis of these observations, he isolated a few races from those already known, e.g., race 40 from 20, 41 from 7, 46 from 45, 47 from 28. The last publication (ref. 18) in the area of yellow rust race specialization describes the discoveries of 1939. At that time, the list consisted of 52.

The files of Braunschweig tests show that Straib has isolated two other races from the Halle Material, 53 and 54, the infection pictures of which he has not published, however.

They are described for the first time in this article. (Table I). Race 53 has been mentioned by Becker (2). Noll (10) described an additional race 55 found since 1950. The Braunschweig material contains race 56 isolated from Agropyron. Manners (9) in 1945-48 found in Cambridge in addition to known races, a new race from Hordeum maritimum. It differs from others by susceptible 0 ♂ on Triticum dicoccum tricoccum, while all others are Type IV.

Manners called it "M". It has been added as Race 57. Race "G" established in the same paper by Manners from Dactylis glomerata was not included in the race list since it has shown "i" on all varieties except Dactylis. This "race" will have to be considered a separate variety.

Table I shows the present complete European race list, Table II gives historical perspective on yellow rust races defined to 1954 and a summary on its incidence.

Works outside Europe have not been considered here. They have not been coordinated with the European ones.

Investigation of rusts collected in 1955 has not been concluded. The heretofore customary classification of races requires revision within the next few years. Some of the utilized test varieties have proved labile as regards temperature, light and humidity so that the small differences in susceptible type found in them are not sufficient for differentiation of races. Especially definition

of races on the basis of variable uredospore germination will not be supportable since these are especially dependent upon environment, Straib (17, 18). Some of the races hitherto described probably have only the nature of biotypes in the sense of Chester (3), and Stakman (12) as indicated by Manners (9). The difficulties of a reasonable and exact classification are far greater in yellow rust than in other rusts owing to greater temperature and light lability in host and fungus.

Therefore, Boniture II, e.g., normally gives a medium type susceptible reaction. Under particular conditions, we may be dealing with a scantily erupting type or a 0 ≠ increased to highest potency. Even at controlled conditions, such types as i, 0, or III and IV cannot be strictly differentiated on some varieties.

Table III shows tabulation of races of P. glumarum found on wheat (with the exception of race 13 on H. jubatum), according to its progressive infection on the Gassner and Straib differentials.

In both tables infection types are grouped for convenience, III and IV to IV; III ≠ and III- to III; [illegible], II, II≠ and II-III to II; and 0≠, 0- I, 0-II, to 0≠. Both tables are meant as a key to determination. It need not be explained in more detail that the practical differentiation depends upon good differentials.

It is difficult to determine the size of a test assortment. On one hand, it should be as small as possible for reasons of

perspective and technical work; on the other hand, it should permit separation of small differences in order to avoid overlooking biotypes and races.

Since its "founding" the Gassner-Straib assortment has proved essentially feasible so far as it enables the worker to maintain the individual varieties constant in their resistance properties. For this reason and in order not to lose the connection with all previous investigations the Gassner and Straib assortment should be generally accepted as a basic stock and augmentation assortments—possibly different in various contries, could be resorted to for extensive differentiation.

The wheat test assortment of Gassner and Straib consists of the following varieties:

1. Michigan Amber (completely susceptible control variety)
2. Blé rouge d'Ecosse
3. Strubes Dickkopf
4. Webster
5. Holzapfels Frühweizen
6. Vilmorin 23
7. Heines Kolben
8. Carsten V
9. Spaldings Prolific
10. Chinese 166
11. Rouge prolifique barbu

Test variety Triticum dicoccum tricoccum is added which is susceptible to all but race 57.

Some varieties such as Webster, Holzapfels Frühweizen, Heines Kolben, and Carstens V do not entirely meet all test variety requirements so that it must be attempted to reselect pure lines with desired properties.

The European Yellow Rust test centers in conjunction with growers institutes will attack this problem together.

The test assortment for determination of yellow rust races occurring on barley and wild grasses consists of the following barley varieties:

A. Weisze von Fong Tien (control)

B. Heils Franken

C. Estanzuela Futter gerste

D. Ackermanns Bavaria

E. Peragis Sommergerste

F. Schwarze zweizeilige

Straibs work shows show difficult it is to find a barley differential assortment at all. The assortment given here is composed from individual publications and certainly is not final.

In the future the cultivation of test differentials will occur at one location from which the three test centers will be supplied with the necessary seed every year.

The Max Planck Institute for cultivation research at Köln-Vogelsang has agreed to furnish these.

In order not to overlook any races and to retest some of the races the Netherlands Grain Center has assembled a catch assortment. This was planted in the fall of 1955 at 38 locations and incorporates the following varieties:

Winterweizen:

1. Aniversario (III)
2. Ardennes (IV)
3. Banco (II)
4. Beauceron (I)
5. Bellevue (II)
6. Blé des Domes (II)
7. Bon Fermier (I)
8. Capelle (III)
9. Carston V (II)
10. Carsten VIII (II)
11. Chinese 166 (V)
12. Condor (II)
13. Elite (IV)
14. Étoile de Choisy (IV)
15. Eroica (II)
16. Florio (II)
17. Funo (IV)
18. Heine IV (II)
19. Heine VII (II)
20. Heine e. 5 (V)
21. Heurtebise (IV)
22. Hybrid 46 (IV)
23. Idéal (III)
24. Ile de France (IV)
25. Jubile (II)
26. Libérator (III)
27. Lille (II)
28. Magdalena (IV)
29. Mariau (III)
30. Marne (IV)
31. Mentana (I)
32. Michigan Amber (I)
33. Ministre (III)
34. Nord (II)
35. Panter (IV)
36. Prima (IV)
37. Provins (II)
38. Reichersberg Stamm 39 (V)
39. Reichersberg Stamm 42 (V)
40. Renfort (III)
41. Rondine (I)
42. Rouvillers (I)
43. Staring (III)
44. Tädepi (III)
45. Vaillant (IV)
46. Vilmorin 23 (II)
47. Vilmorin 27 (III)
48. Vilmorin 53 (III)

Sommerweizen:

49. Aubers (III)
50. Blé d'avril (I)
51. C. I. 12833 (V)
52. Frontana (V)
53. Joncquois (I)
54. Jufy I (II)
55. Peko (IV)
56. Redman (I)
57. Selkirk (V)
58. Thatcher (V)
59. Alter de Gembloux

Explanation:

(I) Very susceptible

(II) Very susceptible for certain yellow rust races

(III) Susceptible

(IV) Somewhat resistant

(V) Good resistance

In addition to varieties of different susceptibility, varieties of different rate of development have been added in order to determine yellow rust infection at different growth stages.

The cultivation of such a test assortment at many locations possibly coupled with a variable time of seeding has been planned for several years in which connection the composition of the assortment probably will be varied. Only those assortments will be treated which have pathological or cultivative interest. The Netherlands Grain Center will cause a scientist to visit the cultivation points to evaluate the reactions. Since it is impossible to arrive at all locations in time, a large number of the cultivators will have to evaluate the reactions themselves. In order to get uniform results, nevertheless, and considering the fact that heretofore evaluation has been conducted with a variety of schemes in the European area, the first European yellow rust conference has worked out a consistent scheme of evaluation based on the schemes of different authors.

In connection with an exact field evaluation which is also informative for epidemiological questions, three different things should be considered:

a. Infection type (as in the greenhouse)

b. Magnitude of infection

c. State of development of host plants

The infection types are given in Roman numerals; the magnitude of infection in Arabic numerals (Table V).

The state of growth of host plants should be evaluated according to Feeke's Scale (4). It has been illustrated by Large (8) and is depicted here in this form, Figure 1. The three schemes are also listed in the new edition of "Handbuch der Pflanzenzüchtung" now in print. (Verlag Paul Parey, Berlin and Hamburg).

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TABLE 1. List of the Races of P. glumarum

Race	Michigan Amber	Ble rouge d'Ecosse	Strubes Dickkopf	Webster	Holzapfels Fruh	Vilmorin 23	Heines Kolben	Carsten V	Spaldings prolific	Chinese 166	Rouge prolifique barbu	Triticum dico. tric.	Kong Tien	Kolls Franken	Estanzuela	Bavaria	Peragis	Schwarze Zweizeilige	Petkuser Roggen	*)
	1	2	3	4	5	6	7	8	9	10	11	0	A	B	C	D	E	F	R	
1	IV	IV	IV	III/	IV	IV	IV	II-	i	i	i	IV	IV-	0					i-0	x
2	IV	IV	IV	IV-	IV	IV	0	II-	III/	i	IV	IV	IV-	0					i-0	x
3	IV	IV	IV	IV-	IV	IV	0	II-	0/	0/	i	IV	IV-	0					i-0	x
4	IV	IV	IV	III	IV	IV-	0	II-	i	i	0/	IV	IV-	0					i-0	
5	IV	IV	IV	IV-	II-	0	0	IV	0/	i	0/	IV	IV-	0					i-0	x
6	IV	IV	IV	IV-	II-	0	0	II-	0/	i	0/	IV	IV-	0					i-0	x
7	IV	IV	IV	0/	II-	0	0	IV	0/	i	0/	IV	IV-	0					i-0	x
8	IV	IV	IV	II-	II-	0	0	II-	0/	i	0/	IV	IV-	0					i-0	x
9	IV	IV	0	III/	IV	0/	IV	0	i	i	i	IV	0	0					i-0	
10	IV	IV	0	0/	0	0	IV	0	i	i	i									
11	IV	IV	0	III	0	0	0	0	i	i	i									
12	IV	IV	0/	0	0	0	0	II-	i	i	i	IV	IV-	0					i-0	
13	IV	0	0	III-	0	0	0	0	i	IV	2	IV	II	0					i-0	
14	IV	0/	0	0	0	0	0	0	i	i	i	IV	IV-	0					i-0	
15	IV	IV	0	0	0	0	0	0	IV	i	0/	IV	IV-	0					i-0	
16	IV	IV	0	III/	IV	I	0/	0	i	i	i	IV	0	0					i-0	x
17	IV	IV	IV	IV-	II-	0	0	II-	IV-	i	0/	IV	IV-	0					i-0	
18	IV	0/	i	0	0	i	0/	i	i	i	i	IV	IV	0					i-0	
19	IV	0	0	0	0	0	IV-	0	i	i	i	IV	IV-	0					i-0	
20	IV	0	0	IV	0	0	III	0	i	i	i	IV	IV-	0					i-0	

TABLE 1. (Cont'd)

Race	Michigan Amber 1	Ble rouge d'Ecosse 2	Strubes Dickkopf 3	Webster 4	Holzapfels Fruh 5	Vilmorin 23 6	Heines Kolben 7	Carsten V 8	Spaldings prolific 9	Chinese 166 10	Rouge prolifique barbu 11	Triticum dic. tric. 0	Fong Tien A	Heils Franken B	Estanzuela C	Bavaria D	Perajis E	Schwarze Zweizeilige F	Petkuser Roggen R	*)
21	IV	IV	i	i-0	0	0	IV	i	i	i	i	IV	IV-	0					i-0	
22	IV	IV	IV	IV-	II-	0	0	II-	IV-	i	III	IV	IV-	0					i-0	
23	0	0	0	i	i	i	0	i	i	II/	0	IV	IV	0	0	0	i	0	i-0	x
24	0	0	i	i	i	i	0	i	i	i	i	IV	IV	IV	0	IV	IV	0/	i-0	
25	IV	0	0	IV-	0	0	0	i	i	i	i	IV	0	0					i-0	
26	IV	IV	IV	II-	II-	0	0	IV	IV	i	0/	IV	IV-	0					i-0	
27	IV	IV	IV	II-	II-	0	0	IV	0	II/	0	IV	IV-	0					i-0	x
28	i-0	i	i	i	i	i	i-0	i	i	i	i	IV	IV-	0					i-0	
29	IV	IV	0	II-	0	0	0	II-	0/	i	0	IV	IV-	0					i-0	
30	IV	II	i	III	0/	0	0/	i-0	0/	i	0	IV	IV-	0					i-0	
31	IV	0	0	IV	0	0	III	0	i	IV	i	IV	III	0					i-0	
32	IV	IV	0	III/	IV	0/	0	0	i	i	i	IV	IV-	0					i-0	
33	II/	i	i	0	i	i	II	i	i	0	0	IV	IV	0					i-0	
34	II/	i	i	i	i	i	0/	i	i	i	i	IV	II	0					IV	
35	IV	IV	IV	III/	IV	IV	IV	0	IV	i	IV	IV	IV-	0					i-0	
36	0	i	i	0	i	i	i-0	i	i	i	i	IV	IV	0					i-0	
37	IV	II	III-	III	II-	0	IV	II	0/	i	0	IV	IV-	0					i-0	
38	IV	II	II	III	0/	0	0/	II	0/	i	0	IV	IV-	0					i-0	
39	IV	II	i-0	III	0/	0	0/	i-II	IV	i	III-	IV	IV-	0					i-0	
40	IV	0	0	III-IV	0	0	III	0	i	i	i	IV								
41	IV	IV	IV	II-III	II-	0	0	IV	0/	i	0	IV	IV-	0						

TABLE 1. (Cont'd)

Race	Michigan Amber	Ble rouge d'Ecosse	Strubes Dickkopf	Webster	Holzapfels Früh	Vilmorin 23	Heines Kolben	Carsten V	Spaldings prolific	Chinese 166	Rouge prolifique barbu	Triticum dic. tric.	Fong Tien	Hells Franken	Zstanzuola	Bavaria	Perags	Schwarze Zweizeilige	Petkuser Roggen	*)
	1	2	3	4	5	6	7	8	9	10	11	0	A	B	C	D	E	F	R	
42	IV	0/	0/	III-	0/	0	II	0	i	IV	i	IV								
43	IV	IV	0	IV	IV	0	0	0	IV	i	IV	IV	IV-	0						
44	IV	II/	0	0	0	0	IV	0	i	i	i	IV	IV-	0						x
45	0	0	0	i	i	i	0	i	i	II/	0	IV	IV	0	II-III					
46	0	0	0	i	i	i	0	i	i	II/	0	IV	IV	0	II-III	0/	i			x
47	0	0	i	i	i	i	0	i	i	i	i	IV	IV	i-0						
48	II											IV	IV	IV	0	IV	IV	II-III		
49	IV	IV	0/	III	IV	0/	0	0	i	i	i									
50	IV	IV	IV	0/	IV	IV	0	0	0/		0/									
51	IV	IV	III	IV-	0	0	0	0	0/	i	0/									
52	IV	III	0	IV	IV	IV	0	0	i	i	i									
53	IV	IV	IV	II	III/	0	0	IV	III-	III/	0	IV	IV-	0						
54	IV	IV	IV	II-	II/	0	IV	IV-	0	i	0-II		IV-							x
55	IV	IV	IV	III-IV	IV	III-IV	0	IV	i-0	i-0	i-0		IV							x
56	0	0	0	0	i-0	i	0	i-0	i	0	0	IV	IV	0	i	0	0	i		x
57	0	0	0	0	0	0	0	0	0	0	0	0-1	III-	0	0-III				i	x

*) Zur Zeit noch in einer der drei Prüfstellen vorhanden.

TABLE 2. (Cont'd)

Literatur	Race	1927/28	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954
Straib 1937 (14)	35									x																		
Straib 1937 (14)	36									x																		
Straib 1937 (14)	37									x																		
Straib 1937 (14)	38									x																		
Straib 1939 (16)	39	(Described by Straib (15) from South America)																										
Straib 1939 (16)	40	(out of race 20)									x	x																
Straib 1939 (16)	41	(out of race 7)									x	x	x															
Straib 1939 (16)	42	(isolated from Japanese material)																										
Straib 1939 (16)	43											x																
Straib 1939 (16)	44											x																
Straib 1939 (16)	45										x																	
Straib 1939 (16)	46	(out of race 45)									x	x							*					x		x		
Straib 1939 (16)	47	(out of race 28)									x																	
Straib 1941 (18)	48												x															
Straib 1941 (18)	49												x										x	x				
Straib 1941 (18)	50												x															
Straib 1941 (18)	51												x															
Straib 1941 (18)	52												x															
	53																											
	54																							x				x
Noll 1955 (10)	55																					x	x					
Z	56																						x					
	57																		*									

x = Data from Gassner, Straib and Noll

* = Data from Manners (9) from 1945 - 1948

TABLE 2. Synopsis of Occurrence of Yellow Rust Races in the Years 1927 - 1954

Literatur	Race	1927/28	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954
Gassner u. Straib 1932 (5)	1				x		x		x		x														x			x
Gassner u. Straib 1932 (5)	2		x		x	x	x	x	x	x	x	x							*	x	x		x	x		x	x	x
Gassner u. Straib 1932 (5)	3			x	x	x	x	x	x	x	x	x	x						*	x								x
Gassner u. Straib 1932 (5)	4	x			x	x	x	x			x								*									
Gassner u. Straib 1932 (5)	5			x	x	x	x	x	x	x		x							*	x			x		x	x		
Gassner u. Straib 1932 (5)	6		x		x	x	x	x	x		x	x	x						*									
Gassner u. Straib 1932 (5)	7				x	x	x	x	x	x	x	x	x						*	x			x	x	x	x	x	x
Gassner u. Straib 1932 (5)	8			x	x	x	x	x	x	x		x	x						*				x	x				
Gassner u. Straib 1932 (5)	9			x	x	x	x	x	x	x	x	x											x	x	x			
Gassner u. Straib 1932 (5)	10				x																							
Gassner u. Straib 1932 (5)	11				x																							
Gassner u. Straib 1932 (5)	12				x	x	x		x				x															
Gassner u. Straib 1932 (5)	13				x																							
Gassner u. Straib 1932 (5)	14				x		x		x																			
Gassner u. Straib 1934a (6)	15					x		x				x	x															
Gassner u. Straib 1934a (6)	16					x	x	x		x	x																	
Gassner u. Straib 1934a (6)	17					x	x	x																				
Gassner u. Straib 1934B (7)	18						x			x																		
Gassner u. Straib 1934b (7)	19						x			x																		
Gassner u. Straib 1934b (7)	20						x		x	x	x																	
Gassner u. Straib 1934b (7)	21						x																					
Gassner u. Straib 1934b (7)	22						x																					
Straib 1935 (13)	23							x	x	x	x	x	x							x			x		x	x	x	x
Straib 1935 (13)	24							x	x			x																
Straib 1935 (13)	25							x																				
Straib 1937 (14)	26								x																			
Straib 1937 (14)	27								x										*									
Straib 1937 (14)	28								x																			
Straib 1937 (14)	29								x																			
Straib 1937 (14)	30								x	x																		
Straib 1937 (14)	31								x																			
Straib 1937 (14)	32								x				x															x
Straib 1937 (14)	33									x		x							*									
Straib 1937 (14)	34									x																		

Race	1 Michigan Amber	2 Ble rouge d'Ecosse	3 Strubes Dickkopf	4 Webster	5 Holzapfels Früh	6 Vilmorin 23	7 Kelnes Kolben	8 Carsten V	9 Spaldings prolific	10 Chinese 166	11 Rouge prolif. barbu	0 Tri. dicocc. triocc.	A Fong Tien	B Heils Franken	C Estanzuela	D Bavaria	E Peragis	F Schwarze Zweizeil	R Petkuser Roggen
53																			
34																			
45																			
46																			
23																			
48																			
24																			
55																			
28																			
47																			
36																			
57																			

*) Race 48 might be placed after Race 34 because of its reaction on Michigan Amber. Because of

TABLE 4

O Tri. dicocc. triocc.	A Fong Then	B Heils Franken	C Estanzuela	D Bavaria	E Peragis	F Schwarze Zweizeil	R Petkuser Roggen	Host	Habitat
		0					·	Hordeum murinum	Europe
		0						Rye	Bulgaria
		0	·	6	·			Barley	Turkey
		0		6	·			Barley	Europe
		0	0	0	·	0	·	Barley	Europe
			0					*) Barley	Europe
			0			G	·	Barley	France
		0	0	0	0			Agropyrum	Germany
		0					·	Agropyrum	Europe
		0						Agropyrum	(out of R. 28)
		1					·	?	France
0		0					·	Hordeum marimun	England

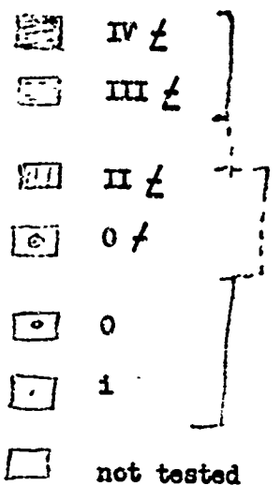
its reaction on Michigan Amber. Because of its great similarily to Race 24, however, it is placed by it

TABLE 3

Race	1 Michigan Amber	2 Blé rouge d'Ecosse	3 Strubes Dickkopf	4 Webster	5 Holzapfels Früh	6 Vilmorin 23	7 Heines Kolben	8 Carsten V	9 Spaldings prolific	10 Chinese 166	11 Rouge prolif. barbu	Tri. dicoc. triocc.	Fong Tien	Habitat
1														Germany
35														Bulgaria
55														Germany
2														Europe
3														Europe
4														Europe
5														Europe
22														Germany
17														Germany
6														Europe
51														Austria
53														
54														N.W. Europe
26														Germany
27														Germany
41														out of R. 7
8														Europe
50														Germany
7														Europe
52														Africa
9														Germany
43														Germany
16														Europe
32														Europe
49														Germany
11														Austria
29														Germany
10														Germany
21														Finland
12														Europe
15														Europe
37														S. America
38														S. America
39														S. America
30														S. America
44														Austria
31														Afghanistan
20														S. Europe
40														out of R. 20
42														Japan
13														Canada
25														Turkey
19														Turkey
14														N. Europe
18														S. Europe

*) Race 13 was isolated for Hordeum jubatum

Code for Tables 3 and 4



Susceptible

Somewhat susceptible to somewhat resistant

Resistant

not tested

Table 5.

Evaluation Scheme

1. Infection type

   i = infection free

   0 = no pustules, chlorosis (c = small, C = large)
   necrosis (n= small N = large)

   I = single very small pustules, chlorosis (c,C),
   necrosis (n,N)

   II = few small pustules, chlorosis

   III = normal eruption of pustules, chlorosis

   IV = normal eruption of pustules, no chlorosis

2. Magnitude of infection

   0 = no infection)
   1 = 1 pustule on 10 m) for epi-
   2 = 1 pustule on 1 m) demiological
   3 = 1 pustule on 0.1 m) researches
   4 = 1 pustule per culm to 1% severity)
   5 = 5% severity
   6 = 10% severity
   7 = 25% severity
   8 = 50% severity
   9 = 75% severity
   10 =100% severity